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The Economic Geology of Brazil [review]

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The Economic Geology of Brazil

A Review by Benjamin L. Miller of an Important Paper Published by Dr. J. C. Branner in Bulletin 30 of the Geological Society of America—Dr. Branner's Areal Map Is Reproduced

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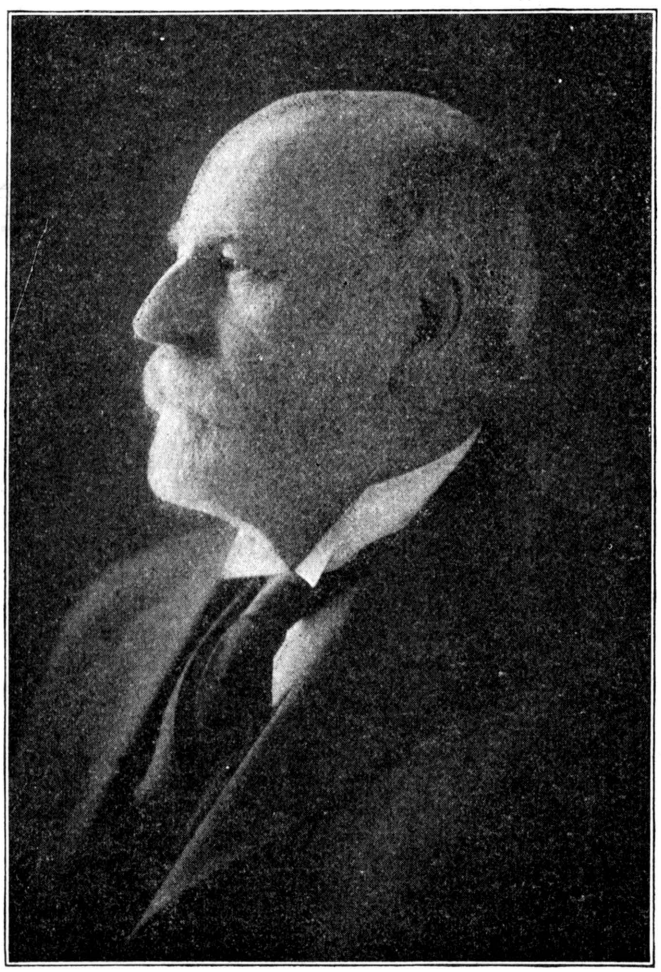
GEOLOGY knows no national boundaries, nor do geologists confine their investigations to their own countries. In many instances, even in the European countries, foreign geologists have furnished the most valuable contributions. It is therefore not surprising to those familiar with geologic literature to learn that the most important geologic article and map of Brazil thus far published are by a North American.



J. C. BRANNER

Dr. John Casper Branner, president emeritus of Leland Stanford Junior University, a geologist of international reputation, and the foremost living authority on the geology of Brazil, has just published a geologic map of Brazil (scale 1 : 5,000,000) with a 150-page article entitled "Outlines of the Geology of Brazil to Accompany the Geologic Map of Brazil," in Vol. 30 of the Bulletin of the Geological Society of America. The basis and objects of the publication are stated by Dr. Branner in the opening paragraphs:

"The accumulation of the data for a geologic map of Brazil was begun by me in 1874, when I first went to that country, and has been kept up, as opportunities offered, down to the present time. The gathering and study of the material and the preparation of the map may therefore be said to represent the work of a considerable portion of a lifetime.

"The data brought together on the map and in the accompanying text are published by the Geological Society of America primarily as a contribution to the world's knowledge of the geology of America; but, so far as I am concerned, it is meant especially to be of service to the Brazilian people, among whom I have spent many years, to whom I am strongly attached, and in whose welfare I am deeply interested."

Comprehensiveness of the Work

The map and text bring together in usable form a summary of the available geologic data of that great country. To one unacquainted with the physical characteristics of Brazil and the numerous obstacles that confront the geologist there, it may be disappointing to note extensive vacant areas such as those in Matto Grosso, Goyaz, and Paraná, but to students of South American geology it is a surprise to learn that there are not more gaps. It is reasonable to say that Dr. Branner has overlooked few sources of reliable information. To his own extensive observations he has added those of the geologists and travelers of many countries.

To make the work useful for those geologists who may wish further details, each state description includes a brief bibliography, as well as a description of sources of the information used in the compilation of the map. The lithologic and economic products of each geologic period are first given, followed by descriptions of each of the twenty-one states.

A map such as this will do much to promote further geologic research and stimulate the development of the undeveloped mineral resources of Brazil. Any mining engineer or geologist who goes to that great Southern Republic should take a copy of this valuable publication with him. It is especially timely on account of the increasing interest in Brazil, and is a worthy companion to Dr. Branner's exhaustive "Bibliography of the Geology, Mineralogy, and Paleontology of Brazil," published in Vol. 20, pp. 1-132, of the Bulletin of the Geological Society of America. With the aid of these two publications it is comparatively easy for a geologist or mining engineer to familiarize himself with Brazilian geology.

Geological Formations Represented in Brazil

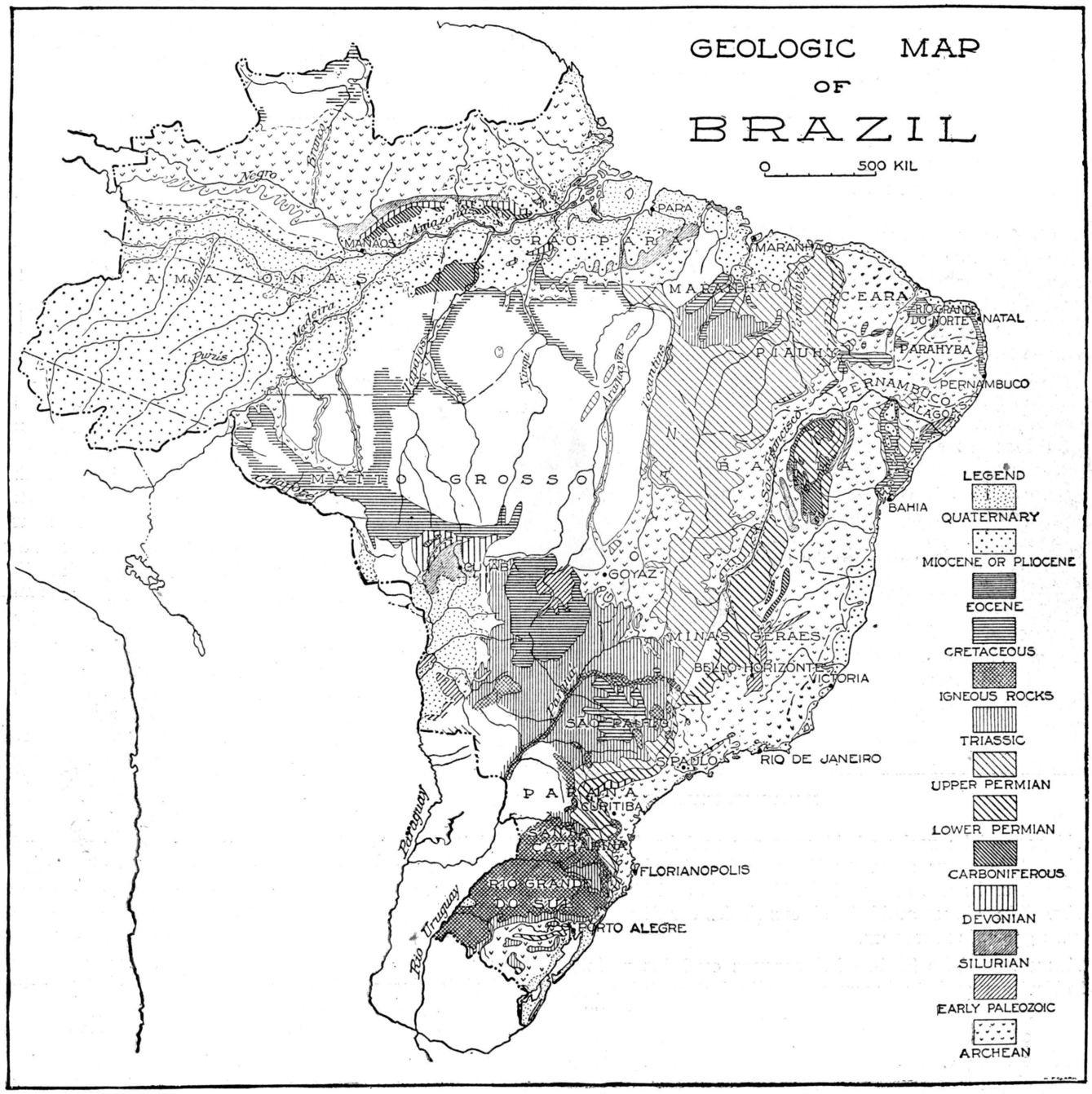
Archean Rocks—The Archean rocks of Brazil include gneisses, quartzites, marbles, and crystalline schists, with pegmatites and dike rocks. These rocks contain deposits of gold, copper, platinum and tungsten ores and mica, marble, talc, apatite, graphite, potash-bearing

minerals, precious stones, and excellent building stones, and are the original source of monazite.

Early Paleozoic Rocks—The Early Paleozoic, mainly undifferentiated, is made up principally of quartzites, schists, itacolumites, marbles, itabirites, and some unmetamorphosed sediments. They contain gold ores in the form of lodes, such as are now worked, and they were the source of the gold in the old placer districts. They also include the great iron and manganese deposits of Minas Geraes and Bahia.

Carboniferous Rocks—The Carboniferous period is represented by quartzites, conglomerates, sandstones, shales, and limestones. The diamonds and carbonados of Bahia and northern Minas Geraes are believed to have been derived from strata of Carboniferous age.

Permian Rocks—The Permian period, which, in Brazil, is unusually well represented and readily divisible into Upper and Lower Permian beds, comprises sandstones, shales, limestones, and glacial till, intruded by eruptive dikes in many places. The economic products



Silurian Rocks—The Silurian strata consists of marine sediments, mainly thin-bedded fossiliferous sandstones.

Devonian Rocks—The strata of Devonian age include conglomerates, sandstones, and shales, in places cut by diabase dikes. They are the supposed source of the diamonds of Paraná. They contain shales used in the manufacture of portland cement.

include the coal beds of Paraná, Santa Catharina, and Rio Grande do Sul, bituminous shales, and limestones suitable for the manufacture of portland cement.

Triassic Rocks—The Triassic rocks are mainly reddish sandstones with a maximum thickness of 500 meters or more.

Cretaceous Rocks—The Cretaceous strata consist of limestones and sandstones. The materials of economic

importance are mainly limestones suitable for building purposes and for the manufacture of lime or portland cement.

Tertiary Rocks—The Tertiary rocks consist of fresh, brackish-water, and marine sediments. They contain some lignites, bituminous shales, and clays.

Quaternary Rocks—The Quaternary sediments consist mainly of alluvial materials.

RÉSUMÉ OF THE GEOLOGICAL FEATURES OF THE BRAZILIAN STATES

Acre—The territory of Acre comprises Late Tertiary undisturbed sands and clays, through which wind sluggish streams. The region is one of dense forests and no roads. Gold is reported from some streams.

Ceará—The Ceará strata consists mainly of Archean granites, gneisses, and schists, but with some Permian, Cretaceous, Tertiary, and Quaternary sediments. Gold has been placered in several places. Iron ores are abundant in many places, but are not worked. Copper ore, bituminous shale, marbles, limestones, and other minerals are known, but their importance is undetermined.

NATURAL BRIDGE NEAR DIAMANTINA, MINAS GERAES

Alagoas—The rocks of Alagoas are mainly Archean rocks. There are some Tertiary sediments along the seacoast, and some areas of old Paleozoic and Permian rocks. Limestones and bituminous shales constitute the known geologic resources.

Amazonas—The State of Amazonas contains mainly late Tertiary and Quaternary deposits, but contains two large areas of Archean rocks and smaller areas of Silurian, Devonian, and Carboniferous sediments. Gold is found in some of the headwaters of the rivers. Limestones, clays, and granites are abundant in various portions. Lignites seem to be widespread in the western portion of the state. Analyses show 33 per cent fixed carbon, 39 per cent volatile hydrocarbons, and 15 per cent ash.

Bahia—The State of Bahia is composed mainly of Archean and metamorphic Early Paleozoic rocks, but with some Late Paleozoic, Cretaceous, and Tertiary sediments. The economic minerals and rocks that have been worked are gold, diamonds, carbonados, amethysts, sands, manganese, bituminous shales, limestones, and pottery clays. Nitrate of potash has been obtained from cave deposits, and salt has been leached from the earth of old lake beds. The undeveloped mineral resources consist of marbles, iron and copper ores, mica, talc, graphite, grindstones, whetstones, and limestones and clays suitable for the manufacture of portland cement.

Espirito Santo—Archean granites, gneisses, and schists, with probably some metamorphosed early Paleozoic rocks, are the surface rocks over all the states of Espirito Santo except along the coast, where Pliocene (?) and later sediments are present in a belt having a width of eighty kilometers in the northern part and twenty kilometers in the southern part. Monazite sands are found in places along the sea beaches north of Victoria, and wolframite is reported from one locality.

Goyaz—The State of Goyaz contains principally Archean rocks, with some areas of old Paleozoics. Permian rocks are present in the northeast portion, and Triassic and Cretaceous strata in the southwest part of the state. Goyaz has produced large amounts of placer gold derived from the Archean schists, and considerable quantities of diamonds and other precious stones. Important deposits of iron ore are present in several places, and bituminous and gypsiferous shales are reported along the Tocantins River.

Maranhão—Some Archean rocks are exposed along

several rivers of Maranhão. Permian sandstones and shales are the surface rocks over about half the state, but with large areas of Triassic, Cretaceous, and Tertiary sediments. Some gold has been obtained, and bauxite, bituminous shales, iron ore, and limestones have been reported from different localities.

Matto Grosso—Little is known of the geology of Matto Grosso, the largest state of Brazil. There seem to be extensive areas of Permian, Triassic, and Cretaceous rocks, with smaller areas of Devonian, early Paleozoic, and Archean rocks. Placer gold and diamonds have been obtained from a number of the streams, and important deposits of manganese and iron ores resembling those of Minas Geraes are found at Urucum, in the southern portion of the state.

MARKET SCENE IN BRAZIL. NATIVE POTTERY DISPLAYED FOR SALE

Minas Geraes—The geology of Minas Geraes is not well understood. The Archean rocks, including many metamorphosed early Paleozoic strata, cover about half the state. The Paleozoic metamorphics are infaulted in the Archean rocks, and in many places appear as parallel ridges or mountains because of their greater resistance to erosion. There are large areas of Permian rocks in the western portion of the state, and several smaller areas of Carboniferous, Triassic, and Tertiary sediments. The following brief account is quoted from Dr. Branner's article:

"Minas Geraes is the chief mining state of Brazil. It has an unusually large number of minerals of economic importance, though only gold, manganese, iron, and diamonds have ever been extensively worked. It was in Minas that gold was first discovered in Brazil, about 1693, and the earliest mining done in that country was for gold in what is now that state. For some years Brazil was the leading gold-producing country of the world. Though there have been and still are a few notable rock mines in the old Paleozoic series where the gold originated, most of the gold of Brazil has come from placer deposits.

"The manganese deposits of Minas first attracted attention in 1893, and in 1894, 1,430 tons of the ore was exported, and since 1896 that state has been one of the great manganese-producing regions of the world. The ores occur at two horizons—in the Archean complex and in the early Paleozoic series of rocks. The mines worked are in the vicinity of Lafayette, in the Archean, and at Miguel Burnier, on the Central Ry., in the Paleozoic. Later discoveries have been made on the properties of the Saint John del Rey Mining Co. at Capitão do Matto and Cachoeirinha, near Morro Velho.

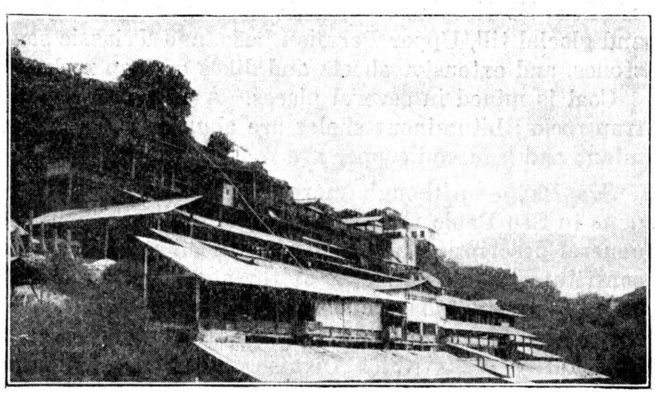
"The iron deposits of Minas have long been known, but only within a few years have they attracted the attention to which they are justly entitled. They are probably the most important iron ores known, though they are as yet but little used. The iron ores are in sedimentary rocks, either in the forming parts of the early Paleozoic rocks, or they are later deposits derived therefrom."

In addition, the following economic products have been found in various places, but remain practically undeveloped: nickel ore, platinum, marbles and limestones, asbestos, talc, mica, niter, graphite, bauxite, phenacite, and bituminous shales. The mineral waters are also of considerable economic importance.

Pará—The lower course of the Amazon flows across the State of Pará in a synclinal trough. Archean rocks are found in the north and south portions of the state, and Paleozoic, Tertiary, and Quaternary rocks occupy the inner portions of the syncline. Some gold has been obtained from the streams that flow directly into the ocean from the crystalline rocks of the northeastern portion, but comparatively little is known of the economic geology of the state.

Parahyba—With the exception of a narrow band of Cretaceous and Tertiary sediments bordering the ocean, and a small area in the western portion, practically the entire State of Parahyba is made up of crystalline rocks of the Brazilian complex, consisting of schists, gneisses, and granites. Gold-bearing quartz veins have been worked in these rocks, but no mines are now in operation. Iron ore deposits are reported, but information concerning them is lacking. Some limestone from the Cretaceous has been quarried, and marble of the crystalline area has been locally quarried for lime.

Paraná—The geology of Paraná is simple. The Archean rocks constitute the eastern portion of the state, and are succeeded westward by early Paleozoic crystallines (called, by Oliveira, the Devonian complex),



PART OF THE CONCENTRATION MILL OF THE AURO PRETO GOLD MINES OF BRAZIL, LTD.

Devonian unmetamorphosed sediments, Lower Permian, Upper Permian and Triassic strata, the latter intruded by sheets and dikes of intrusive rocks. Coal is present in the Upper Permian rocks of the northern portion of the state; diamonds have been mined along some of the streams of the Devonian area; molybdenum is said to occur in the Archean rocks; asphalt veins and bituminous shales are present in the Upper Permian; and limestones are known in many localities.

Pernambuco—Rocks of Archean age cover most of the State of Pernambuco. A band of Tertiary sediments

borders the coast, and small areas of Paleozoic, upper Permian, and Cretaceous rocks are known. The known economic materials consist of marbles and limestones, employed both for building purposes and for lime, sandstones, rhyolites, and phonolites used for building and paving purposes, and some salt and saltpeter obtained as efflorescences from porous sandstones.

Piauhy—Permian strata constitute most of the State of Piauhy, with a few areas of Archean and Cretaceous rocks. It is an agricultural state, and no minerals are worked. Iron ore of excellent quality has been reported, but nothing is now known of the quantity.

Rio de Janeiro—Archean rocks cover all of the state except a narrow belt of Tertiary and Quaternary sediments on the coast and some isolated patches of Tertiary lake deposits in the valley of the Parahyba. The economic geologic products are chiefly building stones and clays.

Rio Grande do Norte—The rocks of the State of Rio Grande do Norte consist mainly of Archean crystallines, with a coastal band of Cretaceous and Tertiary sediments. Clays and glass sands are abundant in the coastal belt, and mica and asbestos are reported from the Archean area.

Rio Grande do Sul—Tertiary and Quaternary sediments constitute the coastal belt, back of which is a band of the Archean crystalline rocks. West of this band are Permian and Triassic strata. The middle and western portions are covered with pre-Cretaceous trap rocks resting on the Triassic beds.

Coal of Lower Permian age is the principal mineral product. Copper and gold have been mined in the region of the older Paleozoic rocks. The state has also furnished many agates derived from the trap rocks. Magnesite, zinc, and molybdenum have been reported. Marble is said to occur in several places.

Santa Catharina—Archean rocks border the coast and constitute the eastern part of the Serra do Mar. West of these lie the Lower Permian rocks, containing coal and glacial till, Upper Permian beds, and Triassic sandstones, and extensive sheets and dikes of trap rocks.

Coal is mined in several places. Agates occur in the trap rocks; bituminous shales are abundant in the Permian; and lead and copper are reported.

São Paulo—Although more geologic work has been done in São Paulo than in any other state of Brazil, no general description has been published. Archean rocks constitute the eastern part of the state, with Permian, Triassic, Cretaceous, and Tertiary sediments in the central and western portions. There are extensive areas of eruptive rocks which furnish the extremely fertile red soils.

The economic geologic products are iron, marble, bituminous shales, building stones, limestones, and ceramic clays. The Ipanema iron ore deposits about a hundred kilometers west of the city of São Paulo furnished the first iron manufactured in Brazil. The iron industry has not been successful, however. Some of the bituminous shales have been used for the manufacture of gas. The marbles have been quarried in several places.

Sergipe—The small State of Sergipe contains rocks belonging to the Archean, Paleozoic, Mesozoic and Cenozoic eras, a greater variety than that found in most of the other states. The economic geologic products seem to consist of limestones and clays.

In the concluding pages of the report Dr. Branner includes a brief résumé of the principal mineral resources of the different states, which is valuable although not exhaustive. He also gives lists of writers who have described the various occurrences. Some of the principal travel books in Brazil are listed, as well as a few good works on the climate.